SAVITRIBAI PHULE PUNE UNIVERSITY

FACULTY OF ENGINEERING

SYLLABUS FOR
M. E. ELECTRICAL
(ELECTRIC VEHICLE TECHNOLOGY)
(2017 COURSE)

WITH EFFECT FROM YEAR 2017-18

F.Y. M.E. (Electric Vehicle Technology)
Semester -I

Subject Code	Course	Teaching Scheme	Examination Scheme				Total	Credits
		Theory/Lab	Paper		TW	Oral/ Presentation		
			ISE	ESE				
503501	Electric Vehicles	04	50	50	-	-	100	04
503502	Vehicle Dynamics	04	50	50	-	-	100	04
503503	Power Electronics Converters	04	50	50	-	-	100	04
503504	Research methodology	04	50	50	-	-	100	04
503505	Elective-I	05	50	50	-	-	100	05
503506	Lab Practice I- Electric vehicles Lab	04	-	-	50	50	100	04
Total		**25**	**250**	**250**	**50**	**50**	**600**	**25**

Elective I	
Code No.	**Title**
503505A	Power Semiconductor Devices
503505B	Automotive Electronics for EVs
503505C	Control Systems and instrumentation in Automotive Systems

Semester -II

Subject Code	Course	Teaching Scheme	Examination Scheme				Total	Credits
		Theory/Lab	Paper		TW	Oral/ Presentation		
			ISE	ESE				
503507	Embedded System	4	50	50			100	4
503508	Battery Management System	4	50	50			100	4
503509	Charging Systems and Infrastructure	4	50	50			100	4
503510	Elective-II	5	50	50			100	5
503511	Lab Practice II Powertrain Lab	4			50	50	100	4
503512	Seminar-I	4			50	50	100	4
Total		**25**	**250**	**250**	**50**	**50**	**600**	**25**

Elective II	
Code No.	**Title**
503510A	Energy Storage Systems and Management
503510B	Electronic System Design
503510C	Thermal Management of EV systems

S.Y. M.E. (Electric Vehicle Technology)

Semester -III

Subject Code	Course	Teaching Scheme	Examination Scheme				Total	Credits
		Theory/Lab	Paper		TW	Oral/ Presentation		
			ISE	ESE				
603501	Advanced Battery Technology for Electrical Vehicles	04	50	50			100	04
603502	Advanced Electrical Machines	04	50	50			100	04
603503	Elective-III	05	50	50			100	05
603504	Seminar-II	04			50	50	100	04
603505	Project Stage -I	08			50	50	100	08
Total		**25**	**150**				**500**	**25**

Elective III	
Code No.	**Title**
603503A	Automotive Testing and Certification
603503B	Automotive Embedded Systems and Communication Protocol
603503C	Modeling and Simulation of EVs

Semester -IV

Subject Code	Course	Teaching Scheme	Examination Scheme				Total	Credits
		Theory/Lab	Paper		TW	Oral/ Presentation		
			ISE	ESE				
603506	Seminar-III	05			50	50	100	05
603507	Project Stage -II	20			150	50	200	20
Total		**25**			**200**	**100**	**300**	**25**

F.Y. M.E. (Electric Vehicle Technology)
Semester -I

[503501]: Electric Vehicles

Teaching Scheme: TH:-04Hours/Week	Credit: 04	Examination Scheme: In Sem.Evaluation:50Marks End Sem.Exam:50Marks Total: 100 Marks

Course Prerequisites: Electrical Circuits, Electrical Machines, Electrical Drives, Power Electronics, Microprocessor and Microcontrollers, Analog and Digital Electronics

Course Objectives:

1	To introduce configurations of EV
2	To design electric vehicle for various applications
3	To select appropriate motor and converter for EV applications
4	To select battery, battery indication system for EV applications
5	To develop battery charger for an EV

Course Contents

UNIT-I	Introduction to EV	08 Hours

Introduction: Past, Present & Future of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine.
EV System: EV Configuration: Fixed & variable gearing, single &multiple motor drive, In-wheel drives EV Parameters: Weight, size, force, energy & performance parameters.

UNIT-II	EV Propulsion-Electric Motor	08 Hours

Choice of electric propulsion system, block diagram of EV propulsion system, concept of EV Motors, single motor and multi-motor configurations, fixed & variable geared transmission, in wheel motor configuration, classification of EV motors, Electric motors used in current vehicle applications, Recent EV Motors, Comparison of Electric Motors for EV applications

UNIT-III	Required Power Electronics &Control	08 Hours

Comparison of EV power devices, introduction to power electronics converter, four-quadrant DC chopper, three-phase full bridge voltage-fed inverter, soft-switching EV converters, comparison of hard-switching and soft-switching converter, three-phase voltage-fed resonance dc link inverter, Basics of Microcontroller &Control Strategies

UNIT-IV	EV Motors	08 Hours

DC Motor: Type of wound-field DC Motor, Torque-speed characteristics, DC-DC Converter, two quadrant DC Chopper, two quadrant zero voltage transition converter- fed dc motor drive, speed control of DC Motor Induction Motor Drive: Three Phase Inverter Based Induction Motor Drive, Equal Area PWM, Three Phase Auxiliary resonant snubber (ARS) Inverter Type (ZVC & ZCS), Single Phase ARS Inverter

Topology, Speed Control of Induction Motor, FOC, Adaptive Control, Model Reference Adaptive Control (MARS), Sliding mode Control		
UNIT-V	**Batteries and Battery management system**	**08 Hours**
Basics: types, parameters–capacity, discharge rate, state of charge, state of discharge, depth of discharge, technical characteristics, battery pack design, properties of batteries, introduction to energy, storage requirements in hybrid and electric vehicles, battery pack development. Introduction, charging algorithm, balancing method for battery pack charging. Battery management system representation: - battery module, measurement unit block, battery equalization balancing unit, MCU Estimation unit, display unit, fault warning block, Thermal monitoring of battery unit.		
UNIT-VI	**Battery Charging**	**08 Hours**
Battery Chargers: Conductive (Basic charger circuits, microprocessor-based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication Methods Charging Infrastructure: Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast charging station, battery swapping station, move on charge zone		

Reference Books

1	C. Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001
2	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC, Press, 2003
3	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
4	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley,2003

F.Y. M.E. (Electric Vehicle Technology)
Semester -I
[503502]: Vehicle Dynamics

Teaching Scheme: TH:-04Hours/Week	Credit: 04	Examination Scheme: In Sem.Evaluation:50Marks End Sem.Exam:50Marks Total: 100 Marks

Course Objectives:

1	Understand the dynamics of vehicle ride under different riding condition.
2	Present a problem oriented in depth knowledge of Vehicle Dynamics.
3	Address the underlying concept and methods behind Vehicle Dynamics
4	Calculate and refer the load and forces associated to the vehicles.
5	Analyze the behavior of the vehicles under acceleration, ride and braking

Course Contents

UNIT-I	**Basics of Vehicle Dynamics**	**08Hours**
History, vehicle classifications, fundamental approaches to vehicle dynamics modeling; SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system, Dynamic axle loads, Equations of motion, transmission characteristics, vehicle performance, Brake proportioning, braking efficiency.		
UNIT-II	**Acceleration Performance**	**08Hours**
Power train components; power and traction limited acceleration; transverse weight shift; front wheel drive vs rear wheel drive vs. all-wheel drive vehicles		
UNIT-III	**Braking Performance**	**08Hours**
Braking force analysis; brake design and analysis; federal regulation non braking performance; antilock braking system; wheel lock-up; tire/road friction; safety and maintenance issues in braking		
UNIT-IV	**Road Loads, Tire and Dynamics**	**08Hours**
Wind drags and car body design, rolling resistance; break downs of total road loads; gas mileage analysis and driving styles; Aerodynamics Tire specifications and constructions; tire motion analysis; tire force analysis; tire contact stress analysis; tire vibration analysis; tire models		
UNIT-V	**Ride &Cornering/steering**	**08Hours**
Riding comfort; perception of vibration; vibration sources; vibration transmission to the passenger's lower speed cornering; high speed corner; cornering bicycle model; Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, Transient Rollover		
UNIT-VI	**Chassis and Suspension Systems**	**08Hours**
Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-		

Pitch Suspension Geometry, Anti-Dive Suspension Geometry, Roll Center Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points, Controllable Suspension	
Reference Books	
1	Fundamentals of Vehicle Dynamics, Thomas Gillespie, SAE Publication.
2	The Multibody systems Approach to Vehicle Dynamics, Mike Blundell and Damian Harty, Elsevier, 2004.
3	Vehicle Dynamics, Theory and Application, Reza N. Jazar, Springer, 2009, ISBN 978-0-387-74243-4, e- ISBN978-0-387-74244-1.
4	Race Car Vehicle Dynamics, W.F. Milliken and D.L. Milliken, SAE,1995, ISBN1-56091-526-9.
5	Reimpell, Stoll and Betzler: The Automotive Chassis: Engineering Principles.
6	Hans Pacejka, Tire and Vehicle Dynamics, Elsevier, 2012
7	Rajesh Rajamani, Vehicle Dynamics & control, Springer.
8	R.V. Dukkipati, Vehicle dynamics, Narsova Publications.

F.Y. M.E. (Electric Vehicle Technology)
Semester -I

[503503]: Power Electronic Converters

Teaching Scheme: TH:-04Hours/Week	Credit: 04	Examination Scheme: In Sem.Evaluation:50Marks End Sem.Exam:50Marks Total: 100 Marks

Course Prerequisites: Knowledge of Power Electronics

Course Objectives:

1	Understand the essentials of power conversion,
2	Design practical non isolated converters
3	Design practical offline converters
4	Design practical isolated converters
5	Bidirectional converter topologies for Electric Vehicles

Course Contents

UNIT-I	**Power Semiconductor Devices**	**08Hours**
Ideal and Typical Power Switching Waveforms, Ideal and Typical Power Device Characteristics, Unipolar Power Devices, bipolar Power Devices, MOS-Bipolar Power Devices		
UNIT-II	**Introduction to Power Conversion**	**08Hours**
Converting power with resistors, Converting power with switches, the duty, buck converter, boost converter, buck-boost Converter, Input filtering, RLC filter		
UNIT-III	**Non-isolated converters**	**08Hours**
Buck converter, Boost converter, Buck-Boost converter, analysis design and simulation		
UNIT-IV	**Off-line Converters—the front end**	**08Hours**
Rectifier Bridge: Capacitor selection, Diode Conduction Time, Rms Current in the Capacitor, Current in the Diodes, Input Power Factor, Hold-Up Time, In-Rush Current Power Factor Correction: Definition of Power Factor, Non-sinusoidal Signals, A Link to the Distortion, Why Power Factor Correction? Harmonic Limits, A Need for Storage, Passive PFC, Improving the Harmonic Content, The Valley-Fill Passive Corrector, Active Power Factor Correction, Constant on-time border in mode (BCM), fixed-frequency continuous mode (CCM), Analytical control law.		
UNIT-V	**Isolated converters**	**08Hours**
Simulations and practical designs of fly back converters, an isolated buck-boost, flyback waveforms		

without parasitic elements, Flyback waveforms with parasitic elements, clamping the drain excursion, designing the clamping network, two-switch flyback, simulations and practical designs of forward converters, an isolated buck converter, need for a complete core reset, a two-switch configuration, two-switch forward and half-bridge driver		
UNIT-VI	**Bidirectional Converter Topologies for Plug-In Electric Vehicles**	**08Hours**
Introduction, Literature Survey, Bidirectional Converters, Bidirectional AC/DC Converters for Plug- In EV with Reduced Conduction Losses, Topology Explanation, Plug-In Charging Mode, Propulsion Mode, Boost Operation, Buck Operation, Regenerative Braking Operation, Boost Operation, Buck Operation, Bidirectional Battery Charger for an Electric Vehicle		

Reference Books

1	B. Jayant Baliga, "PowerSemiconductorDevices",1st Edition, International Thompson Computer Press, 1995
2	Christophe Basso, "Switch Mode Power Supplies: SPICE Simulations and Practical Designs", McGraw- Hill,2008
3	L. Ashok Kumar, S. Albert Alexander, " Power Converters for Electric Vehicles", CRC Press,& Francis Group, 2021

F.Y. M.E. (Electric Vehicle Technology)
Semester -I
[503504]: Research Methodology

Teaching Scheme: TH:-04Hours/Week	Credit: 04	Examination Scheme: In Sem.Evaluation:50Marks End Sem.Exam:50Marks Total: 100 Marks

Course Prerequisites:

Course Objectives:

1	To develop understanding of the basic framework of research process, various research designs and techniques.
2	To identify various sources of information for literature review and data collection.
3	To develop an understanding of the ethical dimensions of conducting applied research.

Course Contents

UNIT-I	**Basics of research**	08 Hours

Definition, Research Characteristics, Research Need, Objectives and types of research: Motivation and objectives – Research methods vs Methodology, Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Research Formulation, Defining and formulating the research problem, Selecting the problem Necessity of defining the problem, Importance of literature review in defining a problem. Using web for literature review, Types of literature: books, papers, reviews, treatise, monographs, patents, process of identifying gap areas from literature review Development of working hypothesis. Different tools for literature survey.

UNIT-II	**Technical Writing:**	08 Hours

Writing Thesis: Structure and components of scientific reports, Types of report – Technical reports and thesis, Significance, Different steps in the preparation, Layout, structure and Language of typical reports. Writing papers: types of technical papers, Journal papers, Conference papers, Survey papers, Poster papers, Comparison, Structure of a survey, conference and journal paper. Writing Research Proposal: Importance of research funding in research, standard formats for different research schemes of AICTE, DST. Preparation for research proposal, how to write a research proposal.

UNIT-III	**Assessment of research output:**	08 Hours

Measure for quality of research, citation index Researcher metrics (i10-index, H-index etc.), Article

metrics, Journal Metrics. Ethical practices in research such as plagiarism, acknowledgment etc. Commercialization of research, Copy right, royalty, Intellectual property rights and patent law, Trade related aspects of Intellectual Property Rights, patent search, drafting and filing patent, legal procedure in granting patent.		
UNIT-IV	**Linear Programming**	08 Hours
Linear Programming : Standard form of a linear programming problem-geometry of linear programming problems-definitions and theorems, linear simultaneous equations: Elimination method, Jacobi's method, Relaxation method solution of the system of pivotal reduction of a general system of equations, simplex method.		
UNIT-V	**Linear Programming**	08 Hours
Constrained Nonlinear Programming : Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method, Introduction to Convex Programming Problem. Finite Difference approximations of partial derivatives.		
UNIT-VI		08 Hours
Following methods with applications to particular problem of Electrical Engineering: Genetic algorithm, Simulated Annealing method, PSO, GA, SAM, Ant Colony method, ARIMA, Linear regression, Multi regression.		
References		
1	Research Methodology: Methods and Techniques: C.R. Kothari	

F.Y. M.E. (Electric Vehicle Technology)
Semester -I

[503505A]: Power Semiconductor Devices

Teaching Scheme: TH:-05Hours/Week	Credit: 05	Examination Scheme: In Sem. Evaluation:50Marks End Sem. Exam:50Marks Total: 100 Marks

Course Prerequisites: Knowledge of Power Electronics

Course Objectives:

1	To identify various power semiconductor devices and their ratings for various power electronic application.
2	To understand the static and dynamic characteristics of voltage and current controlled power semiconductor devices
3	To enable the students, the knowledge of selection of devices for different power electronics Applications
4	To understand the control and Gate Drive requirements for different power devices.

Course Contents

UNIT-I	**Power Diodes**	**08Hours**
On-state losses, switching characteristics-turn-on transient, turn-off transient and reverse recovery transient, Schottky diodes, series and parallel connections of diodes, snubber requirements for diodes, diode snubber**.**		
UNIT-II	**Power BJT'S**	**08Hours**
On state losses, switching characteristics, resistive switching specifications, clamped inductive switching specifications, turn-on transient, turn-off transient, storage time, base drive requirements, switching losses, device protection-snubber requirements for BJT'S and snubber design-switching aids.		
UNIT-III	**Gate Turn off Thyristor (GTO)**	**08Hours**
Basic structure and operation, GTO switching characteristics, GTO turn-on transient, GTO turn-off transient, minimum on and off state times, gate drive requirements, maximum controllable anode current, over current protection of GTO'S.		

UNIT-IV		08Hours
Basic structure, V-I characteristics, turn-on process, on state operation, turn-off process, switching characteristics, resistive switching specifications, clamped inductive switching specifications - turn-on transient and di/dt limitations, turn-off transient, turn off time, switching losses, effect of reverse recovery transients on switching stresses and losses - dv/dt limitations, gating requirements, gate charge-ratings of MOSFET'S,FBSOA and RBSOA curves, device protection–snubber requirements, MOSFET drivers and protection, Miller region		
UNIT-V	**Insulated Gate Bipolar Transistors (IGBT'S)**	**08Hours**
Basic structure and operation, latch up IGBT, switching characteristics, resistive switching specifications, clamped inductive switching specifications - IGBT turn-on transient, IGBT turn off transient- current tailing-gating requirements -ratings of IGBT'S, FBSOA and RBSOA curves, switchinglosses-minimumonandoffstatetimes-switchingfrequencycapability–overcurrent Protection of IGBT'S, short circuit protection, snubber requirements and snubber design. IGBT drivers and protection, Active clamping.		
UNIT-VI	**New Power Semiconductor Devices**	**08Hours**
MOS gated thyristors, MOS controlled thyristors or MOS GTO'S, base resistance-controlled thyristors, emitter switched thyristor, thermal design of power electronic equipment, modeling and simulation, heat transfer by conduction, transient thermal impedance-heat sinks, heat transfer by radiation and convection-heat sink selection for power semiconductor devices		

Reference Books

1	Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics Converters, Applications, and Design", 3rd Edition. Wiley India Pvt Ltd, 2011.
2	G. Massobrio, P. Antognetti, "Semiconductor Device Modeling with Spice", McGraw-Hill,2nd Edition, 2010**.**
3	B. Jayant Baliga, "Power Semiconductor Devices", 1stEdition, International Thompson Computer Press, 1995
4	V. Benda, J. Gowar, and D. A. Grant, "Discrete and Integrated Power Semiconductor Devices: Theory and Applications", John Wiley & Sons, 1999
5	Benda, J. Gowar, and D.A. Grant, "Discrete and Integrated Power Semiconductor Devices: Theory and Applications", John Wiley & Sons, 1999.

F.Y. M.E. (Electric Vehicle Technology)
Semester -I

[503505B]: Automotive Electronics for EVs

Teaching Scheme: TH:-05Hours/Week	Credit: 05	Examination Scheme: In Sem. Evaluation:50Marks End Sem. Exam:50Marks Total: 100 Marks

Course Prerequisites: Basic Electronics Engineering, Power Electronics, Electric Vehicle mobility

Course Objectives:

1	Understand the electrical and electronic systems in vehicles
2	Understand the principles of networking
3	Explain requirements and types of bus systems
4	Comprehend the lighting systems in vehicles
5	Understand the auxiliaries and chassis electric systems in automobiles.

Course Contents

UNIT-I	**Electrical And Electronic Systems in the Vehicle**	**8Hours**

Overview, Electronic diesel control, Lighting technology, electronic stability program, Adaptive cruise control, Infotainment System. Network topology & organization, OSI reference model, Control mechanisms.

UNIT-II	**Automotive networking**	**8Hours**

Cross-system functions, Requirements for bus systems, Classification of bus systems, Applications in the vehicle, coupling of networks, Examples of networked vehicles system.

UNIT-II	**Bus systems**	**8Hours**

CAN bus: Applications, Topology, Data transmission system, CAN protocol, data transfer sequence, standardization, characteristics. bus: Introduction, features, data transfer, administrative functions, Application layer Bluetooth: Overview, applications, Bluetooth versions, transmission technology, power

classes, topology, physical data channel, physical connections.		
UNIT-IV	**Lighting system**	**8Hours**
Architecture. Lighting fundamentals Lighting circuits, Gas discharge and LED lighting, Case studies, Diagnosing lighting system faults, Advanced lighting technology, new developments in lighting Systems.		
UNIT-V	**Auxiliaries in vehicles**	**8Hours**
Wind screen washers and wipers, signaling circuits, Other auxiliary systems, Case studies, Diagnosing auxiliary system faults Advanced auxiliary systems technology, new developments in auxiliary systems.		
UNIT-VI	**Chassis Electrical systems**	**8Hours**
Chassis Electrical systems. Anti-lock brakes, Active suspension, Traction control, Automatic Transmission, Other chassis electrical systems, Case studies, Diagnosing chassis electrical system faults, Advanced chassis systems technology, new developments in chassis electrical systems.		
Reference Books		
1	Robert Bosch Gmb H, "Bosch Automotive Electrics and Automotive Electronics", 5th Edition. John Wiley & Sons Ltd, 2007.	
2	William B. Ribbens,"UnderstandingAutomotiveElectronics",6thEdition,Elsevier, 2003.	

F.Y. M.E. (Electric Vehicle Technology)
Semester -I

[503505C]: Control Systems and Instrumentation in Automotive Systems

Teaching Scheme: **TH:-05 Hours/Week**	**Credit: 05**	**Examination Scheme:** **In Sem. Evaluation:50Marks** **End Sem. Exam:50Marks** **Total: 100 Marks**
Course Prerequisites: Control System, Basic Electronics Engineering.		
Course Objectives:		
1	To discuss the sensor and measuring system of automobile.	
2	To infer the knowledge of various automotive standards and Protocols.	
3	To elaborate the design of basic modeling and control scheme for automotive systems.	
Course Contents		
UNIT-I	**Control System in Vehicle**	**8Hours**
Control system representation for vehicles, controllability and stability analysis. Closed loop Electric Vehicle system. Speed control techniques control system.		
UNIT-II	**Measurement Analysis**	**8Hours**
Measurement characteristics, selection criteria, reliability considerations, measurement of harmonics in EV system		
UNIT-III	**Digital Control Systems**	**8Hours**
Introduction of linear control system analysis design approaches, as well as digital control system implementation. Linearization, linear equation solutions, z-transforms, and Laplace transforms, linear Controller design, optimum control, and digital implementation of control schemes are covered. For problem-solving and control system design, students will utilize MATLAB.		
UNIT-IV	**Automation & EVS**	**8Hours**

EV design, building, operation, application, and computer systems for controlling, sensing, and processing information. From quantum technologies to energy-efficient communications networks.		
UNIT-V	**Automotive Instrumentation**	**8Hours**
Basic sensor arrangement, types of sensors such as oxygen sensors, crank angle, position sensors, Fuel metering/ vehicle speed sensors, flow sensor, temperature, air, mass flow sensors, throttle position sensor, solenoids etc		
UNIT-VI	**Application of EV and ECU**	**8Hours**
Introduction of automobile system, current trends in automobiles with emphasis on increasing role of electronics and software, overview of generic automotive control ECU functioning		
Reference Books		
1	Automotive Electrical Equipment by Young A.P., Griffiths, ELBS& New Press, 1999.	
2	Understanding Automotive Electronic by Bechhold, SAE,1998.	
3	Understanding Automotive Electronics by William B. Ribbens, Butterworth Heinemann Woburn,6th	

F.Y. M.E. (Electric Vehicle Technology)
Semester -I
[503506]: Lab Practice-I
Electric Vehicles Lab

Teaching Scheme: **Lab:04 Hours/Week**	**Credit:04**	**Examination Scheme:** **TW Evaluation: 50 Marks** **OR/ Presentation: 50 Marks** **Total: 100 Marks**
Course Prerequisites: Electrical Machines-I&II, Power electronics		
Course Objectives:		
1	To understand the Electric vehicle model.	
2	To develop Battery management system.	
3	To apply knowledge gained about EV drives& speed control of various different type of motors used for EV.	
Lab Contents		
Electric Vehicle Lab		
1	To study about the controller and its output of Electrical Vehicle	
2	Study and obtain the parameters of Electric vehicle trainer at no load.	
3	Study and obtain the speed of Electric vehicle trainer at load.	
4	To study the Fault analysis in BLDC motor of Electrical Vehicle.	
5	Study of Charging &discharging characteristic of BMS (Battery Management System).	
6	Study of cell balancing phenomenon of Battery Management System(BMS)	
7	Study load characteristic of PMSM motor	

8	Study of load characteristic of PMDC Motor.
9	Study of load characteristic of BLDC Motor.

F.Y. M.E. (Electric Vehicle Technology)
Semester -II
[503507]: Embedded Systems

Teaching Scheme: TH: 04Hours/Week	Credit: 04	Examination Scheme: In Sem.Evaluation:50Marks End Sem.Exam:50Marks Total: 100 Marks

Course Prerequisites: Electrical Circuits, Electrical Machines, Electrical Drives, Power Electronics, Microprocessor and Microcontrollers, Analog and Digital Electronics

Course Objectives:

1	To familiarize the concept of embedded system
2	To identify various processing element so embedded system and their structure
3	To introduce various memory elements used in embedded systems
4	To understand various interfacing devices used with embedded systems
5	To introduce the concept of Real Time Operating Systems

Course Contents

UNIT-I	**Introduction**	**08Hours**
Embedded systems overview-design challenge-optimizing metrics-processor technology-IC technology		
UNIT-II	**Processing Elements**	**07Hours**
Custom single purpose processor design-RT level custom single purpose processor design- optimizing custom single purpose processors-General purpose processor ‘s software: architecture, operation, programmers view and development environment–ASIPs-selecting a microprocessor- general purpose processor design.		
UNIT-III	**Memory**	**09Hours**

Introduction-memory write-ability and storage permanence, common memory types- composing memory-memory hierarchy and caches-advanced RAM.		
UNIT-IV	**Interfacing**	**09Hours**
Introduction-communication basics-microprocessor interfacing: I/O addressing, interrupts, DMA-Arbitration- multilevel bus architectures-advanced communication principles-serial protocols-parallel protocols-wireless protocols-Standard single purpose processor's peripherals: timers, counters, watchdog timers ,UART, PWM, LCD controllers, keypad controllers, stepper motor controllers, ADC and RTC.		
UNIT-V	**Introduction to Real-Time Operating Systems**	**08Hours**
Software architectures, real-time systems, Basic functions of RTOS kernel, tasks and states, tasks and data, semaphores and shared data, Message Ques, Mailboxes and Pipes		

Reference Books

1	Frank Vahid and Tony Givargis, Embedded system design: A unified hardware/Software introduction, Third edition, John Wiley & sons, 2010.
2	Embedded System Premier, David E Simon, Addison Wesley
3	Embedded System 2nd Edition by Raj Kamal, Tata McGraw-Hill Education
4	Wayne Wolf , Computers as Components: Principles of Embedded Computing System Design, Morgan KaufmanPublishers,2008.
5	Santanu Chattopadhyay, Embedded system Design, PHI LearningPvt.Ltd.,2010
6	Steave Heath, Embedded system Design, Second edition,2003
7	Daniel D. Gajski, Samar. Abdi, Andreas. Gerstlauer Embedded system design: Modeling, Synthesis and verification, Springer,2009
8	Jonathan. W. Valvano, Embedded Microcomputer systems: Real Time Interfacing, Third edition, Cengagelearning,2012
9	Frank Vahid and Tony Givargis, Embedded system design: A unified hardware/Software introduction, Third edition, John Wiley & sons, 2010.

F.Y. M.E. (Electric Vehicle Technology)
Semester -II
[503508]: Battery Management System

Teaching Scheme: TH: 04Hours/Week	Credit: 04	Examination Scheme: In Sem.Evaluation:50Marks End Sem.Exam:50Marks Total: 100 Marks

Course Prerequisites: Electrical Circuits, Electrical Machines, Electrical Drives, Power Electronics, Microprocessor and Microcontrollers, Analog and Digital Electronics

Course Objectives:

1	To introduce the various Battery Management System parts
2	To understand basic information about batteries
3	To measure different battery parameters
4	To estimate state of charge of the battery
5	To estimate state of health of the battery

Course Contents

UNIT-I	**Battery Management System parts**	**06Hours**
The Power Module (PM), The battery, The DC/DC converter, load, communication channel, Examples of Battery Management Systems, Comparison of BMS in a low-end and high-end shaver, Comparison of BMS into types of cellular phones		
UNIT-II	**Basic information on batteries and Lithium-Ion Batteries**	**08Hours**

Battery systems, Definitions Battery design, Battery characteristics, General operational mechanism of batteries, Basic thermodynamics, Kinetic and diffusion over potentials, Double-layer capacitance, Battery voltage, Battery Operation, Battery Construction, Battery Chemistry, Safety Longevity, Performance, Integration		
UNIT-III	**Measurement of battery parameters**	**08Hours**
Cell Voltage Measurement, Current Measurement, Current Sensors Current Sense Measurements, Synchronization of Current and Voltage, Temperature Measurement, Measurement Uncertainty and Battery Management, System Performance		
UNIT-IV	**Battery Management System Functionality**	**08Hours**
Charging, Strategies, CC/CV Charging Method, Target Voltage Method, Constant Current Method, Thermal Management, Operational Modes, Balancing Strategies, Balancing Optimization, Charge Transfer Balancing, Flying Capacitor, Inductive Charge Transfer Balancing, Transformer Charge Balancing, Dissipative Balancing, Balancing Faults, SOC Algorithms: Challenges, Definitions, Coulomb Counting, SOC Corrections, OCV Measurements, Temperature Compensation, Kalman Filtering, Other Observer Methods		
UNIT-V	**State-of-Health Estimation Algorithms**	**08Hours**
State of Health, Mechanisms of Failure, Predictive SOH Models Impedance Detection, Passive Methods, Active Methods, Capacity Estimation, Self-Discharge Detection Parameter Estimation, Dual-Loop System, Remaining Useful Life Estimation		
UNIT-VI	**Fault Detection**	**08Hours**
Overview, Failure Detection, Overcharge/Overvoltage, Over-Temperature, Overcurrent Battery Imbalance/Excessive Self-Discharge, Internal Short Circuit Detection, Detection of Lithium Plating, Venting Detection, Excessive Capacity Loss, Reaction Strategies		

Reference Books

1	H. J. Bergveld, "Battery management systems: Design by Modelling" University Press Facilities, Eindhoven,2001
2	Phillip Weicker, "A Systems Approach to Lithium-Ion Battery Management ", Artech house, 2014
3	GregoryL. Plett," Battery Management Systems: Battery Modeling",Artechhouse,2015
4	M. Barak (Ed.), T. Dickinson, U. Falk ,J.L. Sudworth, H.R. Thirsk, F.L. Tye, "Electrochemical Power Sources: Primary& Secondary Batteries", IEE Energy Series 1, A. Wheaton &Co, Exeter, 1980.

F.Y. M.E. (Electric Vehicle Technology)
Semester -II
[503509]: Charging Systems and Infrastructure

Teaching Scheme: **TH: 04Hours/Week**	**Credit: 04**	**Examination Scheme:** **In Sem.Evaluation:50Marks** **End Sem.Exam:50Marks** **Total: 100 Marks**

Course Prerequisites: Knowledge of Power Electronics

Course Objectives:

1	To describe vehicle electrification and impact of charging strategies.
2	To discuss the influence of EVs on power system.
3	To discuss about the evaluation of the charging and facility planning.

Course Contents

UNIT-I	**Basics of Chargers**	**08Hours**
Types of Chargers, Charging power components		
UNIT-II	**Components of Charger**	**08Hours**
Selection and design of components.		
UNIT-III	**Charging and Chargers Standard**	**08Hours**

International standards, Bi-directional chargers, On-board chargers		
UNIT-IV	**Charging Infrastructure**	**08Hours**
Charging infrastructure design, Charging infrastructure requirements		
UNIT-V	**Charging Policies**	**08Hours**
Roadmap, different charging policies and government initiative sand challenges		
UNIT-VI	Converters for Plug-in EV	**08Hours**
Bidirectional AC/DC Converters for Plug-In EV with Reduced Conduction Losses, Topology Explanation, Plug-In Charging, Bidirectional Battery Charger for an Electric Vehicle		

Reference Books

1	Mohammad S.Alam, Reji Pillai, Murugesan Navaneetha Krishnan, Developing Charging Infrastructure and Technologies for Electric Vehicles, IGI Global
2	Ashok Kumar, S. Albert Alexander,“ Power Converters for Electric Vehicles”, CRC Press, Taylor & Francis Group, 2021.

F.Y. M.E. (Electric Vehicle Technology)

Semester -II

[503510A]: Energy Storage Systems and Management

Teaching Scheme: **TH: 05Hours/Week**	**Credit: 05**	**Examination Scheme:** **In Sem.Evaluation:50Marks** **End Sem.Exam:50Marks** **Total: 100 Marks**

Course Prerequisites:

Course Objectives:

1	To understand working of different types of electric vehicles.
2	To explain the battery parameters.
3	To understand different types of batteries.
4	To illustrate battery charging and modeling
5	To introduce novel and alternate energy sources.

Course Contents

UNIT-I	**Types of Electric Vehicle**	**08Hours**

Battery electric vehicles, The IC engine/electric hybrid vehicle, fuel electric vehicles, Electric vehicles using supply lines, Solar powered vehicles, Electric vehicles which use flywheels or super capacitors, Electric Vehicles for the Future		
UNIT-II	**Battery Parameters**	**08Hours**
Electrochemical Batteries, Cell and battery voltages, Charge (or amp-hour) capacity, Energy stored, Specific energy, Energy density, Specific power, amp-hour (or charge) efficiency, Energy efficiency. Self-discharge rates, Battery geometry, Battery temperature, Battery life and number of deep cycles.		
UNIT-III	**Types of Batteries**	**08Hours**
Lead Acid Batteries, Nickel-based Batteries: Introduction, Nickel cadmium, Nickel metal hydride batteries, Sodium- based Batteries, Lithium Batteries, Metal Air Batteries,		
UNIT-IV	**Battery Charging and Modeling**	**08Hours**
Battery Charging, Battery chargers, Charge equalization, The Designer's Choice of Battery, Use of Batteries in Hybrid Vehicles, Internal combustion/battery electric hybrids, Battery/battery electric hybrids, Combinations using flywheels, Complex hybrids, Battery Modeling, the purpose of battery modeling, Battery equivalent circuit, Modelling battery capacity, Simulation a battery at a set power, Calculating the Peukert Coefficient, Approximate battery sizing		
UNIT-V	**Alternative and Novel Energy Sources and Stores:**	**08Hours**
Introduction, Solar Photovoltaic, Wind Power, Flywheels, Ultracapacitors, Super Capacitors, Supply Rails,		
UNIT-VI	**Hydrogen Fuel Cells**	**08Hours**
Hydrogen Fuel Cells: Basic Principles, Hydrogen Storage I: Storage as Hydrogen, Hydrogen Storage II: Chemical Methods		
Reference Books		

1	James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd.,UK, Electric Vehicle Technology Explained
2	M. Barak (Ed.), T. Dickinson, U.Falk, J.L. Sudworth, H.R. Thirsk, F.L. Tye," Electrochemical Power Sources: Primary & Secondary Batteries", IEE Energy Series 1, A. Wheaton &Co, Exeter, 1980.
3	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004

F.Y. M.E. (Electric Vehicle Technology)
Semester -II

[503510B]: Electronic System Design

Teaching Scheme: TH: 05Hours/Week	Credit: 05	Examination Scheme: In Sem.Evaluation:50Marks End Sem.Exam:50Marks Total: 100 Marks

Course Prerequisites:	
Course Objectives:	
1	To discuss different design parameters and requirement of power supplies.
2	To elaborate about the design of filters and regulators.
3	To elaborate about the design of inverter and driver circuits.
4	To discuss about design of UPS.
Course Contents	

UNIT-I	**Design of Power Supplies:**	**08Hours**
IC based linear power supplies, Switched mode power supply topologies - forward, Fly back, Push – pull, Bridge, SMPS IC's, Magnetic component requirement and design,		
UNIT-II	**Design of Filters and Regulators**	**08Hours**
Filter design, Voltage regulation, Load regulation, EMI/EMC considerations, Design of PI controller.		
UNIT-III	**Design of Inverter and driver circuit**	**08Hours**
Design of Inverter, Design of driver circuit with isolation and protection for single phase half – bridge inverter and full-bridge inverter, PWM circuit design for single–phase and three–phase inverter, Power circuit design.		
UNIT-IV	**Protection and Selection**	**08Hours**
Protection circuit needs and heat sink design, Selection of ratings of components and power devices, Signal sensing and its conditioning.		
UNIT-V	**Design of UPS**	**08Hours**
Design of UPS system: Type of UPS, Battery charger design, Selection of battery bank, Ah capacity, Back – up time, Topologies of UPS, Redundancy, Bypass mechanism, Controller features, Harmonics at supply side and load sides, Applications.		
UNIT-VI	**Sensors and Actuators**	**08Hours**
Introduction, types of sensors, sensor characteristic, sensor response, sensor error, Redundancy of sensors in ECU		

Reference Books

1	Manohar Lotia, Modern Digital Inverter Intro, Servicing & T/S Paperback–1January2004.
2	Pressman AI, Switching Power Supply Design 2Ed (Pb2015)Paperback–1January2015
3	Dr. J S Chitade, Power Electronics: A conceptual approach, Technical publications.

F.Y. M.E. (Electric Vehicle Technology)
Semester -II
[503510C]: Thermal Management of EV systems

Teaching Scheme: **TH: 05Hours/Week**	**Credit: 05**	**Examination Scheme:** **In Sem.Evaluation:50Marks** **End Sem.Exam:50Marks** **Total: 100 Marks**

Course Prerequisites: Engineering Physics, Basic Electrical& Electronics, Analog & digital electronics, Power electronics.

Course Objectives:

1	To understand thermal management of electronics.
2	To understand the importance of thermal resistance network.
3	To understand thermal management of microelectronic packages.
4	To comprehend the concepts of cooling techniques.
5	To explain thermal management systems.

Course Contents		
UNIT-I	**Introduction to thermal management of Electronics**	**08Hours**
Semiconductor Technology Trends, Temperature Dependent Failures Temperature Dependent Electrical Failures, Importance of Heat Transfer in Electronics, Thermal Design Process		
UNIT-II	**Thermal Resistance Network**	**09Hours**
Thermal Resistance Concept, Series Thermal Layers, Parallel Thermal Layers General Resistance Network, Thermal Contact Resistance, Interface Materials, Spreading Thermal Resistance, Thermal Resistance of Printed Circuit Boards (PCBs)		
UNIT-III	**Fins and Heat Sinks**	**07Hours**
Fin Equation, Infinitely Long Fin, Adiabatic Fin Tip Convection and Radiation from Fin Tip, Constant Temperature Fin Tip Fin Thermal Resistance, Effectiveness, and Efficiency with Variable Cross Sections. Heat Sink Thermal Resistance, Effectiveness, and Efficiency, Heat Sink Manufacturing Processes.		
UNIT-IV	**Advanced Cooling Technologies**	**10Hours**
Pipes, Capillary Limit, Boiling Limit. Sonic Limit, Entrainment Limit, Other Heat Pipe Performance Limits, Heat Pipe Applications in Electronic Cooling, Thermosyphons, Liquid Cooling		
UNIT-V	**Thermal Specification of Microelectronic Packages**	**10Hours**
Importance of Packaging, Packaging Types, Specifications of Microelectronic Packages, Junction-to-Air Thermal Resistance, Junction-to-Case and Junction-to-Board, Thermal Resistances, Package Thermal Characterization Parameters, Parameters Affecting Thermal Characteristics of a Package		

Reference Books	
1	Younes Shabany, “Heat Transfer: Thermal Management of Electronics” 2010, CRC Press.
2	Jerry Sergent, Al Krum, “Thermal Management Handbook: For Electronic Assemblies Hardcover”, 1998, Mc-Graw- Hill.
3	“Vehicle thermal Management Systems Conference Proceedings”,1stEdition ;2013, Coventry Techno centre, UK
4	T.Yomi Obidi,“ Thermal Management in Automotive applications”, 2015, SAE International

F.Y. M.E. (Electric Vehicle Technology)
Semester -II
[503511]: Lab Practice-II: Power-train Laboratory

Teaching Scheme: **TH: 04Hours/Week**	**Credit: 04**	**Examination Scheme:** **TW:50 Marks** **OR/Presentation: 50 Marks** **Total: 100 Marks**

Course Prerequisites: Electrical Machines-I&II, Power electronics.

Course Objectives:

1	To study conventional vehicle fuel economy and efficiency.
2	To understand the working of transmission control module.
3	To study hybrid electric vehicle (HEV) multimode reference application.
4	To understand hybrid electric vehicle (HEV)input power-split reference application
5	Study of Electric Vehicle reference application using MATLAB

Lab Contents	
Power train Laboratory	
1	Study of Conventional Vehicle Spark-Ignition Engine Fuel Economy and Emissions using MATLAB
2	Study of Conventional Vehicle efficiency using MATLAB
3	Study of conventional vehicle reference application to optimize the transmission control module (TCM) shift schedules using MATLAB
4	Study of hybrid electric vehicle (HEV)multimode reference application using MATLAB
5	Study of conventional vehicle reference application to optimize the transmission control module (TCM) shift schedules to design control algorithms
6	Study of conventional vehicle reference application to optimize the transmission control module (TCM) shift schedules to assess the impact of power train changes, such as an engine O rgear ratio, on performance, fuel economy, and emissions.
7	Study of hybrid electric vehicle (HEV) input power-split reference application using MATLAB.
8	Study of HEV P0 reference application using MATLAB
9	StudyofHEVP1reference application using MATLAB

F.Y. M.E. (Electric Vehicle Technology)
Semester -II
[503512]: Seminar-I

Teaching Scheme: **TH: 04Hours/Week**	**Credit: 04**	**Examination Scheme:** **TW:50 Marks** **OR/Presentation: 50 Marks** **Total: 100 Marks**

Seminar I shall be on the state-of-the-art topic of student's own choice based on relevant specialization approved by an authority. Topic should cover the advancement on the technology under specialization. The content of seminar report may include basic theory, concept, schematics, models, methods, economics, merits, demerits etc. relevant to the selected topic of seminar. A student should study enough papers from referred journals related to the topic in consultation with the guide. A guide should maintain

a weekly record of discussion related to the topic. The student shall submit the seminar report in standard format, duly certified by the concerned Guide and Head of the department/institute for satisfactory completion of the work.

F.Y. M.E. (Electric Vehicle Technology)
Semester -III
[603501]: Advanced Battery Technology for Electrical Vehicles

Teaching Scheme: **TH: 04Hours/Week**	**Credit: 04**	**Examination Scheme:** **In Sem.Evaluation:50Marks** **End Sem.Exam:50Marks** **Total: 100 Marks**
Course Prerequisites:		
Course Objectives:		
1	To understand electrical vehicle operation& battery basics	
2	To study the electric vehicle battery requirement and battery efficiency	

3	To explain electric vehicle battery charging methods
4	To understand electric vehicle fast charging discharging behavior
5	To understand electric vehicle battery performance

Course Contents

UNIT-I	**ELECTRIC V EHICLE BATTERIES**	**08 Hours**
Electric Vehicle Operation, Battery Basics, Introduction to Electric Vehicle Batteries, Fuel Cell Technology, Choice of a Battery Type for Electric Vehicles		
UNIT-II	**ELECTRIC VEHICLE BATTERY EFFICIENCY**	**08 Hours**
Effects of VRLA Battery Formation on Electric Vehicle Performance, Regenerative Braking, Electric Vehicle Body and Frame, Fluids, Lubricants, and Coolants, Effects of Current Density on Battery Formation, Effects of Excessive Heat on Battery Cycle Life, Battery Storage, The Lithium-ion Battery, Traction Battery Pack Design		
UNIT-III	**ELECTRIC VEHICLE BATTERY CAPACITY**	**08 Hours**
Battery Capacity, The Temperature Dependence of Battery Capacity, State of Charge of a VRL ABattery, Capacity Discharge Testing of VRLA Batteries, Battery Capacity Recovery, Definition of NiMH Battery Capacity, Li-ion Battery Capacity, Battery Capacity Tests, Energy Balances for the Electric Vehicle		
UNIT-IV	**ELECTRIC VEHICLE BATTERY CHARGING**	**08 Hours**
Charging NiMH Batteries, Rate of Charge, Effect on Charge, Acceptance Efficiency of Traction, Battery Packs, Environmental Influence son Charging, Charging Methods for NiMH Batteries, Charging Technology, Battery Pack Corrective Actions		
UNIT-V	**ELECTRIC VEHICLE BATTERY FAST CHARGING**	**08 Hours**
On-board &off-board charging, The Fast-Charging Process, Fast Charging Strategies, The Fast Charger Configuration, Using Equalizing/Leveling Chargers, Inductive Charging, Making Recharging Easier, Range Testing of Electric Vehicles Using Fast Charging, Electric Vehicle Speedometer Calibration. Wireless Charging		
UNIT-VI	**ELECTRIC VEHICLE BATTERY DISCHARGING**	**08 Hours**
The Battery Performance Management System, BPMS Thermal Management System, The BPMS Charging Control, High-Voltage Cabling and Disconnects, Safety in Battery Design, Battery Pack Safety, Electrolyte Spillage and Electric Shock, Charging Technology, Electrical Insulation Breakdown Detection, Electrical Vehicle Component Tests, Building Standards, Ventilation		

Reference Books

1	Electric vehicle battery systems by Sandeep Dhameja, Newnes Publishing, 2002

F.Y. M.E. (Electric Vehicle Technology)
Semester -III
[603502]: Advanced Electrical Machines

Teaching Scheme: **TH: 04Hours/Week**	**Credit: 04**	**Examination Scheme:** **In Sem.Evaluation:50Marks** **End Sem.Exam:50Marks** **Total: 100 Marks**

Course Prerequisites:

Course Objectives:

1	To understand electrical BLDC motor

2	To understand electrical Stepper Motor
3	To understand Switched Reluctance Motors

Course Contents

UNIT-I	**BLDC Motor**	**08 Hours**
Permanent Magnet materials, Permanent Magnet Brushless DC Motors-Construction, operating principle& features of permanent magnet brushless (PMBL)motors, various types of PMBL motors, magnetic circuit model, armature reaction, derivation of emf and torque equation, types of emf generated, performance characteristics, control of PMBLDC motors,		
UNIT-II	**Stepper Motor**	**08 Hours**
Concept of Stepper Motors, types and operating principle of stepper motors, static and dynamic characteristics of stepper motors, stepper motor converters		
UNIT-III	**Switched Reluctance Motors**	**08 Hours**
Construction as well as operating principle and features of switched reluctance motors (SRM), equivalent magnetic circuit, inductance profile, derivation of torque equation and factors, affecting torque.		
UNIT-IV	Control Strategies of Switched Reluctance Motors	**08 Hours**
Performance characteristics, control of SRM, various types of converters, vector diagram, control and topological advancements of synchronous reluctance motors.		
UNIT-V	**Permanent Magnet Synchronous Motor (PMSM)**	**08 Hours**
Construction, Principle of Operation, EMF Equation, Torque Equation, Phasor Diagram, Circle Diagram, Comparison of Conventional and PMSM, Control of PMSM, Applications.		
UNIT-VI	**Case Study**	**08 Hours**
Case studies considering applications viz. electric vehicle		

Reference Books

1	Electric Machines D.P. Kothari, I.J. Nagrath Mc Graw Hill 4th edition,2011
2	Theory of Alternating Current Machines Alexander Langsdorf McGraw Hill 2nd Edition,2000

F.Y. M.E. (Electric Vehicle Technology)
Semester -III
[603503A]: Automotive Testing and Certification

Teaching Scheme: **TH: 05Hours/Week**	**Credit: 05**	**Examination Scheme:** **In Sem.Evaluation:50Marks** **End Sem.Exam:50Marks** **Total: 100 Marks**
Course Prerequisites:		
Course Objectives:		

1	Discuss working and operation of testing of EV. 2. 34.
2	Discuss different methods of testing.
3	Elaborate the schemes and regulations of testing.
4	Discuss working and operation of testing of charging stations

Course Contents

UNIT-I	**Basic of types of EV and Testing**	**08Hours**
Specification& Classification of Vehicles (including M, N and O layout), Homologation &its Types.		
UNIT-II	**Schemes and Regulations**	**08Hours**
Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, homologation for export, Conformity of Production, various Parameters		
UNIT-III	**EV Testing–I**	**08Hours**
Instruments and Type sofestracks, Static testing of vehicles-CMVR physical verification, Tyre Tread Depth Test		
UNIT-IV	**EV Testing–II**	**08Hours**
Electric vehicle–Safety Norms, Energy consumption and Power test,		
UNIT-V	**Testing of Stations**	**08Hours**
Dynamics testing of vehicles, Vehicle component testing. Tests for HEV and charging stations.		
UNIT-VI		**08Hours**
Tests for HEV and charging stations.		

Reference Books

1	Clemens Guhmann, Simulation and Testing for Vehicle Technology, Springer International Publishing AG

F.Y. M.E. (Electric Vehicle Technology)
Semester -III
[603503B]: Automotive Embedded Systems and Communication Protocol

Teaching Scheme: **TH: 05Hours/Week**	**Credit: 05**	**Examination Scheme:** **In Sem.Evaluation:50Marks** **End Sem.Exam:50Marks** **Total: 100 Marks**
Course Prerequisites: Microcontroller		

Course Objectives:	
1	To study the automotive embedded system overview
2	To understand the automotive hardware module
3	To study automotive software and its communication.

Course Contents

UNIT-I	AUTOMOTIVE EMBEDDED SYSTEM OVERVIEW	8Hours

Automotive Embedded System Technology, Overview of Embedded System Categories, Various Embedded Sub Systems like Chassis, Body, Driveline, Engine, Fuel, Emission, Brakes, Suspension, Emission, Brakes, Suspension, Doors, Safety& Security, Comfort & Multimedia, Communication & Lighting and Future Trends in Automotive Embedded Systems by Wire technologies.

UNIT-II	AUTOMOTIVE HARDWARE MODULE	8Hours

Concept to Market: Understanding Automotive Product Design Cycle, Microcontroller, architecture, Memory map, I/O map, Building Blocks of Automotive Electronic Product: Actuators, Sensors, Semiconductor Components, Devices, Integrated Circuits (ICs), Relay, Stepper motor , PCB setc.

UNIT-III	AUTOMOTIVE SENSORS	8Hours

Automotive Sensors and Transducers: Temperature, Force, Oxygen Sensor, LAMBDA Sensor, Proximity Distance Sensors, Speed, Engine Knock Sensor, Resistive Potentiometer & Flow. Typical Sensors Specifications & Microcontroller Interfacing, Signal Processing circuit, Sensor Calibration.

UNIT-IV	AUTOMOTIVE SOFTWARE	9Hours

Structure of embedded program, infinite loop, and compiling, linking and locating, downloading and debugging, Intra processor Communication Protocols: I2C&I2S, SPI & USB, LIN and CAN. Coding Standards and Guidelines: MISHRAC &Automotive Operating System: OSEK/VDX, AUTOSAR.

UNIT-V	VERIFICATION & VALIDATION	9Hours

The Validation and Verification Process, Introduction to NI Lab VIEW for Automotive, Test Categories like Functional Test, Black Box Test, Boundary level Test & Test Case Development, Reliability and Certifications Tests: EMI / EMC Tests as per AIS 004 standard, Environmental Test, Vibration Tests, Protection against Dust, Water Ingress and IP Standards Vehicle Diagnostic Interface Like OBD, OBD-II.

Reference Books

1	Miroslaw Staron, “Automotive Software Architectures: An Introduction”, Springer, 2017. (ISBN: 978-3-319-58609-0)
2	Nicolas Navet and Francoise Simonot-Lion, “Automotive Embedded Systems Handbook”, CRC Press, 2009. (ISBN: 978-0-8493-8026-6)
3	Ronald K. Jurgen, “ Distributed Automotive Embedded Systems”, SAE International, 2007. (ISBN: 978-0-7680-1966-7)
4	Ronald K. Jurgen, “Automotive Software”, SAE International, 2006. (ISBN:978-0-7680- 1714-4).

F.Y. M.E. (Electric Vehicle Technology)
Semester -III
[603503C]: Modeling and Simulation of EVs

Teaching Scheme:	Credit: 05	Examination Scheme:
TH: 05Hours/Week		In Sem.Evaluation:50Marks

		End Sem.Exam:50Marks **Total: 100 Marks**

Course Prerequisites: Matlab, Electrical Machines, Electric Vehicle mobility

Course Objectives:

1	Elaborate basic concepts of modeling of electrical machines and discuss reference frame theory.
2	Derive the DC machine model under transient and steady state conditions.
3	Obtain the dynamic model of 3phase induction machines using reference frame theory.
4	Derive the single-phase and three-phase transformers model & analyze the per unit model of the 3 phase transformer.
5	Illustrate the synchronous machine modeling and obtain its per unit equivalent**.**

Course Contents

UNIT-I	**Basic Concepts of Modeling**	**8Hours**

Basic Concepts of Modeling 05 Hours Basic two pole machine representation of commutator machines, 3-phase synchronous machine with and without damper bar and 3-phase induction machine, Kron's primitive machine-voltage, current and torque equations.

UNIT-II	**Reference Frame Theory**	**8Hours**

Hours Realtime model of a two-phase induction machine, transformation to obtain constant matrices, three phase to two phase transformation, power equivalence. DC Machine Modeling

UNIT-III	**DC Machine Modeling**	**8Hours**

Mathematical model of separately excited DC motor-steady state and transient state analysis, sudden application of inertia load, transfer function of separately excited DC motor, mathematical model of dc Series motor, shunt motor, linearization techniques for small perturbations

UNIT-IV	**Dynamic Modeling of Three Phase Induction Machine**	**8Hours**

Generalized model in arbitrary frame, electromagnetic torque, derivation of commonly used induction motor models-stator reference frames model, rotor reference frames model, synchronously rotating reference frames model, equations in flux linkages, per unit model,

UNIT-V	**Transformer Modeling**	**8Hours**

Introduction, single phase transformer model, three phase transformer connections, per phase analysis, normal systems, per unit normalization, per unit three phase quantities, change of base, per unit Analysis of normal system, regulating transformers for voltage and phase angle control.

UNIT-VI	**Concepts in Simulation**	**8Hours**

Introduction to system modeling Continuous System Simulation-Introduction Probability Theory Queuing Theory -Introduction General description of GPSS and Modeling principles and concepts Numerical solution of differential equations Probability, Case Study.

Reference Books

1	R. Krishnan, "Electric Motor Drives-Modeling, Analysis Control", PHI LearningPrivateLtd,2009.
2	P.C. Krause, Oleg Wasynczuk, Scott D. Sudhoff," Analysis of Electrical Machinery and Drive Systems", 2ndEdition, Wiley(India),2010.
3	Arthur R Bergen and Vijay Vittal," Power System Analysis", 2nd Edition,Pearson,2009.
4	Chee-Mun Ong, "Dynamic Simulation of Electric Machinery using Matlab /Simulink", Prentice Hall,1998.
5	

F.Y. M.E. (Electric Vehicle Technology)
Semester -III
[603504]: Seminar-II

Teaching Scheme: TH: 04Hours/Week	Credit: 04	Examination Scheme: TW:50 Marks OR/Presentation: 50 Marks Total: 100 Marks

Seminar II shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization and based on broader area of interest to facilitate to proceed for dissertation work, selected by him/her approved by the guide and authority. He/she should study basic theory related to the topic from standard references. A student is expected to perform an exhaustive literature review of the topic. The student should focus on understanding the state of art – concept, literature published at standard platforms to enable the finalization of objective of his/her ME dissertation. A guide should maintain a weekly record of discussion related to the topic. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and head of the department/institute.

S.Y. M.E. (Electric Vehicle Technology)
Semester -III

[603505]: Project Stage-I

Teaching Scheme: 08 Hours/Week	Credit: 08	Examination Scheme: Term Work: 50 Marks Oral /Presentation: 50 Marks Total: 100 Marks

Project work Stage – I is an integral part of the project work. In this, the student shall complete the partial work of the project which will consist of problem statement, literature review, project overview, scheme of implementation (Mathematical Model/block diagram/ PERT chart, etc.) simulation model, Layout & Design of the Set-up and results if obtained. As a part of the progress report of Project Stage-I, the student shall deliver a presentation on the advancement in Technology pertaining to the selected dissertation topic. The project stage I is the progress presentation of dissertation work. The student should clearly present different stages in which dissertation work is to be completed, giving planning of the remaining part to be completed in Project Stage-II. Publication based on the work is desirable in the reputed national or international journal or in the proceedings of reputed and reviewed conferences. A guide should maintain record of discussion related to the topic; work carried out by the student. The student shall submit the duly certified progress report of Project work Stage-I in standard format for satisfactory completion of the work by the concerned guide and head of the Department / Institute.

Semester -IV
[603506]: Seminar-III

Teaching Scheme: TH: 05 Hours/Week	Credit: 05	Examination Scheme: Term Work: 50 Marks Oral Presentation: 50 Marks Total: 100 Marks

Seminar III shall preferably be an extension of seminar II. The content of report of seminar III will include development of the work till date along with relevant theory. A guide should maintain record of discussion related to the topic, work carried out by the student, action taken etc. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

S.Y. M.E. (Electric Vehicle Technology)
Semester -IV
[603507]: Project Work Stage-II

Teaching Scheme:	Credit: 20	Examination Scheme:
TH: 20 Hours/Week		Term Work: 150 Marks Oral Presentation: 50 Marks Total: 200 Marks

In Project Work Stage – II, the student shall complete the remaining part of the project which will consist of simulation, fabrication of set up required for the project, workstation, conducting experiments and taking results, analysis & validation of results and conclusions. A student must publish a minimum of one paper based on the dissertation work in the reputed national or international journal or in the proceedings of reputed and reviewed conferences. Details of this publication should be mentioned in the final report. The dissertation work of candidate would be evaluated by the guide as well as panel of internal/external experts, before submitting it to the university to ensure basic minimum quality standard. A proper record of this evaluation needs to be maintained. A guide should maintain a record of discussion related to the topic, work carried out by the student, action taken etc. The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work by the concerned guide, head of the Department and head of the Institute.